A Decision-Making Model for Forest Managers using Economic Considerations

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Part Two: Production Policy (Modelling More Than One Acre)

In Part One, silvicultural options were selected on the basis of their net PV rating without further thought of their effect on the future levels of wood flow.

While each single-acre silvicultural option has a different net PV rating, each may also have a different level of timber productivity. (For example, the do-nothing option may provide a higher PV rating than intensive silvicultural effort, but it doesn't produce much wood). The levels of productivity which result from the silvicultural package options are a function of the levels of success, desirable species and stocking which records show those treatments to have and the resultant adjustment to yield tables.

In our economic production model we shall consider a management forest with a finite landbase available for growing timber, an annual volume target assigned by the provincial Production Policy and a variety of investment opportunities characterized by alternative sites, locations and treatments. We still further assume that the target has been broken down by species and product as clearly as an uncertain future permits. In our example, the silvicultural option with the highest PV rating is selected and applied against the landbase available to it until that associated landbase has been exhausted. The next highest PV option is then selected and similarly applied, and so on. While our first dollar spent provides the highest possible, return, it will require more dollars of a lower economic efficiency to meet the mill requirements or the production policy target for the management unit.

The process stops when the landbase has been exhausted, the volume target achieved or the declining marginal benefits no longer acceptable. The purpose is to determine the extent of the landbase, silvicultural effort and funding that is necessary to meet the volume or value-added target where silviculture is practised on an economic efficiency basis.

In the event that the landbase is exhausted before the volume is achieved it remains possible to substitute higher intensity silvicultural options of a lower economic efficiency but higher timber productivity. In the opposite case where not all of the landbase is required, forest management efforts need not be undertaken on the remainder of the area.

The associated levels of silvicultural effort by treatment type form the production policy implementation schedule for the unit. Should funding constraints be placed upon the unit, these should be applied in reverse; i.e., by removing the silvicultural packages with the lowest PV ratings first, not by removing pieces of high-rating options.

Unlike the PV model, the economic production policy calculation is a cumbersome one, especially where the volume target includes a number of species and products. For multi-product situations a linear programing approach is preferable wherever computer facilities are available.

Case Study No. 2, the Beta Management Unit provides a working demonstration of the production policy calculation.

Introduction

In 1972, the Government of Ontario established a new rationale and basis for its management program, entitled "A Forest Production Policy for Ontario". This policy reviewed the role of the forest industry in the economy of Ontario, the forecast of world demand for forest products, market share and share potential, and the price tag attached to each of its policy options for growing industrial timber. As a result, an annual timber production target of 25.8 million m^3 (9.1 million cunits) by the year 2020 was selected for the province.

The 25.8 million m^3 production target is apportioned to the various administrative regions and districts of the Ministry of Natural Resources, and to the individual forest management units. The target is not broken down by product or species but the volumes produced must be suited to the industry's future needs. The level of silvicultural effort required to bring the target volume on stream was estimated for each management unit, and this became the Ministry's basis for individual funding levels, treatment targets and accountability systems.

In 1983 a review of the MNR's forest strategies identified a need to raise the efficiency of silvicultural investments, considering economic factors in addition to the traditional biological factors. In the light of the current scale of the program and the intense competition within it for silvicultural funding, this need has become increasingly acute. While the recognition has become more widespread among forest managers, there remains the need for an availability and greater use of simple financial tools at the field level.

The purpose of this paper is to develop a simple decision-aiding model[1] which incorporates economic considerations and, secondly, to test its applicability on two representative Ontario forest areas. For the tests, two case study areas were selected: a spruce forest ('Alpha' forest) and a jack pine-poplar forest (Beta Management Unit).

Models, including economic models, are nothing more than mannequins, something on which to hang a new idea and see how it looks. The purpose of this model is to make one more tool available to forest managers, to cast another light on the host of factors which are important to forestry decision-making and priority-setting.

[1]The approach used here was inspired largely by W.F. Hyde in Timber Supply, Land Allocation and Economic Efficiency. (Hyde, 1980).

Case Study No. 2: The Beta Management Unit (A Forest Production Model)

The Beta Management Unit

The Beta Management Unit is a tract of Crown land situated in northern Ontario.

Much of the Unit is made up of deep, well-drained waterlaid sands, and variable-depth sandy loam till soils over bedrock. Jack pine and trembling aspen are the characteristic species on the Unit representing 60% of the production forest area. Jack pine occurs in large pure stands on the deep, dry sands or in association with poplar, black spruce, balsam fir and white birch on the fresher sands, sandy loams and silt loams. Poplar occurs in pure stands or predominates in similar species associations on the fresher sands, sandy loams and silt loams. The age class distribution of both working groups is dominated by 60-year-old stands, the result of the Great Fire of 1922. There is also a large spruce working group. A comprehensive soil survey of the area is available.

The Unit is an important source of supply for several mills. There is a strong demand for jack pine for sawlogs and chips, spruce sawlogs and pulpwood and for poplar tree-length. Balsam fir is utilized for sawlogs wherever the size and quality is suitable. Only white birch is bypassed in any quantity.

The Unit has a Production Policy target of 57,000 cunits annually, of which 24,000 cunits is to be in jack pine, 24,000 in poplar and 9,000 in spruce. This represents a maintenance of the present diversity of species and products.

Large-scale and intensive regeneration efforts have been made on the Unit since the mid 1960's. Sites on which poplar is capable of good performance, and where poplar would be an excessively aggressive competitor to planted jack pine, are managed for poplar. The most common silvicultural package for jack pine management includes a mechanical site preparation of the fresh cutover using the Bracke patch scarifier on deep sands or Young's Teeth on till soils, followed by a hand planting of jack pine container stock at a rate of 1,000 trees per acre. The main competitor to the planted stock is poplar. The regeneration effort is sometimes followed by a tending operation which consists of an aerial application of 2,4-D herbicide. The costs for each of these treatments, derived from MNR silvicultural records, is shown in constant 1983 dollars in Table 2.

Part One: Net Present Value (Making Single-Hectare Forestry Decisions)

Silvicultural efforts are financial investments. They represent expenditures made at a point in time with the expectation of a future gain made possible by real growth. Like financial investments, they require periodic attention and a continuity of management input. No one buys stocks or, worse yet, commodity futures and then forgets about them. Not all plantations. Not all investments provide the same rate of return nor do all silvicultural efforts.

The Concept of Net Present Value Analysis

Where timber production is practised on an economic basis, it is the goal of the landowner or forest manager to maximize the net present value of timber production on any one hectare of land. The single-hectare present value maximization method is standard in the literature. Net present value is the expected value to be realized from harvesting the hectare minus the costs of silvicultural effort, all discounted back to present using conventional interest tables.

The question of profitability, an inevitable one, is dependent upon the costs, failure rate, harvest values, rotation age and interest rate of the timber production regime, more of which will be discussed in this paper. At this point it shall suffice to say that stumpage values alone can justify few silvicultural ventures in Ontario (which explains why private landowners here do not invest in timber production in a meaningful way). The Ontario government makes investments in silviculture because the economic value to society of wood is far greater than the Crown dues alone.

For any one silvicultural option the present value (PV) of the harvest minus the costs may be calculated and compared to that of alternative options, the forest manager then selecting the one with the highest PV rating. This also allows for comparison with the do-nothing option, an option which costs nothing but produces little wood. It allows, too, for comparisons between different hectares of land which are competing with one another for the manager's limited financial resources and silvicultural attention.

Net present value is represented by the formula:

$$PV = \frac{V}{(1+i)^r} - \frac{C}{(1+i)^n}$$

Where PV = Present Value
V = the expected harvest value
C = the cost of silvicultural effort
i = the interest rate
r = the rotation age
and n = the time of silvicultural expenditure where the present is defined as year zero

In reality, silvicultural efforts are more typically packages of site preparation, regeneration and tending, each treatment being made at a different point in time. If commercial thinnings are to be made the harvest values may similarly occur as a series, each also at a different point. To complicate things further, certain of the treatments may not *always* be necessary and the costs must therefore be assigned in proportion to the probability of treatment necessity. If the silvicultural package has a known or estimated rate of failure, the harvest values must also be proportionately reduced, since the investment sometimes produces no wood.

The PV formula is therefore custom-made to accommodate the particulars of the silvicultural options being examined. Examples of more elaborate PV formulae may be seen in the case studies on pages 13 and 15.

The Beta Management Unit
Table 2: Summary of Silvicultural Treatment Costs

Silvicultural Treatment	Cost Per Acre (Constant 1983 $)
Mechanical Site Preparation	
— Bracke on deep sands[1]	$35.08
— Young's Teeth on shallow tills[1]	$50.11
Container Stock[2]	$71.60
Tree Planting	
— Container Stock on deep sands[1]	$76.66
— Container Stock on till soils[1]	$82.41
Tending[3] (2,4-D herbicide applied aerially)	$13.56

[1]Based on a sample of 5,177 acres of treatment carried out between 1972 and 1977 on the Beta Management Unit and assessed between 1977 and 1982. The costs shown were derived from MNR silvicultural project records and inflated to constant 1983 dollars.

[2]Based on the average 1982 production cost of MNR greenhouses, excluding capital and some overhead, inflated to constant 1983 dollars and planted at 1,000 trees/acre.

[3]Based on actual MNR costs.

The Production Policy Model

For the sake of simplicity in demonstrating the production policy model, only the jack pine and poplar working groups shall be considered. Modelling two working groups combined will, however, demonstrate the ability of management and the model to cross working group boundaries; i.e., the option to grow poplar on present jack pine area and jack pine on present poplar area shall remain open. Because soil type has an effect on silvicultural treatment package options and on costs and success rates, a third variable, soil type, has been added to the model. Again for the sake of simplicity in the demonstration, the soil types identified by soil survey have been grouped into four main types: deep sands, shallow sandy loam tills over bedrock, deep sandy loam tills and deep silt loams.

The first step in the production policy model is the calculation of the net PV rating for each of the silvicultural package options. These are shown separately for poplar and jack pine for several soil types (all those on which data are available) in Tables 3a, 3b and 3c. Included in these tables are the associated costs (dollar input), M.A.I. levels and value-added (dollar output).

The next step in the process is to select the package with the highest net PV rating and to apply it against the land base available to it until the target has been achieved or the landbase exhausted. The next best option is then selected and similarly applied, and so on. Table 4 displays the process for the Unit.

The Pure Forestry Factors

As with any numerical analysis, the present value methodology provides an analysis only as good as the numbers which have been plugged in. The numbers used always represent per unit area values.

The silvicultural package to be evaluated in comparison to other available options must be based upon the advice of practising foresters with some local expertise. It must be a silviculturally viable option. The silvicultural costs are fairly straightforward. These may be obtained from past silvicultural records, negotiated Forest Management Agreement rates or detailed cost estimates. If past cost records are used, these must be updated to current dollars using inflation factors such as those provided in Appendix 2. The silvicultural packages and the cost per acre[1] figures are usually easily obtained and reasonably reliable.

e.g. A silvicultural package for the regeneration of a deep, fresh, fine sand to jack pine might consist of: mechanical site preparation using the Bracke (today) at a cost of $35.08/acre, followed by planting 1,000 container stock/acre, in year one ($120.00/M for stock, $76.66/acre for planting) and followed by the 50% probability of an aerially applied 2,4-D tending treatment in year four at a cost of $13.56/acre. The Calculation using a 3% real interest rate would be:

$$PV(\text{costs}) = \$35.08 + \frac{\$120.00 + \$76.66}{1.03} + \frac{13.56}{(1.03)^4} \times 50\%.$$

$$= \$232.04/\text{acre}$$

It is the question of the nature of the stand which the package will produce, its rotation age and the value of the harvest which will, of necessity remain somewhat hypothetical. The rate of failure of the treatment package should, wherever possible, be based upon past regeneration surveys for similar operations on similar sites and under similar conditions. The rate of failure is used to reduce proportionately the harvest volumes for those acres on which silvicultural effort is expended but no wood is produced (or upon which retreatment is required).

While the regeneration survey will provide the species composition, age, height and stocking of the new stand at year five, it remains to project these variables to rotation age. If permanent sample plots are available in comparable timber types, then these should be used to adjust for trends in species composition and overall stocking over time. If these or other reliable sources are unavailable, the stand may be projected on the basis of the informed judgement of experienced local foresters, keeping in mind that the analysis will be only as good as the numbers which have been assigned.

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[1]Throughout costs are expressed on a per acre, and imperial rather than metric units have been used since historical records were in this form.

A word of explanation is necessary on the derivation of some of the figures shown in Table 4. The area by working group and site class was obtained from the 1978 F.R.I. inventory. The area by soil type, working group and site class came from a compilation of the soil survey, with some adjustment necessary since the two surveys, forest inventory and soils, did not correspond exactly. It was assumed that the entire area (124,312 acres) could be placed in jack pine if so desired. This is not true of poplar, since the silvicultural package (clearcut and leave) requires a poplar component to obtain root coppice regeneration. In this case any poplar stand, and any jack pine stand with at least a 25% poplar content was eligible to grow poplar, if so desired. These areas are shown in the row labelled Potential Production Area (acres). Several other assumptions were made. It was assumed that the present site class break-down of either working group was representative of the soil type as a whole. In this way the potential area could be given by site class for either jack pine or poplar. Similarly, when land was allocated for any one silvicultural package, the effect of its withdrawal on the remaining lands could be assessed by site class.

Now let's start with Tables 3 and 4 spread out before us. Poplar silvicultural package S-1 (clearcut and leave) had the highest PV rating of all at $634.44, on any class 1 poplar site. The present area is small, 2,489 acres, but could be expanded to 3,025 acres by allowing any jack pine stand with a 25% poplar content or better on such a site to convert naturally to poplar following clearcutting. We then allocate all 3,025 acres to poplar and deplete the remaining landbase by this amount according to soil type and proportionate site class. We have produced only 2,178 cunits of wood, all poplar so far.

e.g. Let us assume that regeneration surveys of our previous example indicate a 90% success rate and an 80% stocked stand of Pj_7Po_3[1], free-to-grow at age five. The advice of experienced local foresters suggests relative stability in species composition on these sites where jack pine is given a fast start, but that overall stocking has the ability to reach full stocking levels before rotation age. We may then project our new stand to its maturity for the calculation of yield from appropriate yield tables.

Ontario has not been through a full rotation of managed stands nor has it had sufficient opportunity to construct yield tables on plantation-growth trees. The use of wild forest yield tables for managed or semi-managed forests is based upon the premise that the same species will behave in a similar fashion on the same sites and that the yield estimate can be adjusted for the new species composition, stocking, cull factors, regeneration period and rotation age. It cannot account for any different behaviour of the new stand caused by controlled spacing. At any rate, wild forest yield tables may be the best available for our purposes.

e.g. Ontario Yield Tables (Plonski, 1960) indicate that our previous site class 1 jack pine example will have a rotation age of 45 years (based on M.A.I. culmination) and will yield 17.8 cunits of jack pine and 7.6 cunits of poplar, given its projected species composition and stocking at maturity.

The Economic Factors

Because the net PV model asks our silvicultural venture to bear a compound interest rate, it is extremely sensitive to the rate of interest, the rotation period and the value of the harvest.

The rate at which our society discounts the future is reflected in the interest rates of lending institutions. In this paper a 'real' interest rate of 3% has been used in all calculations, real interest representing the difference between market interest rates and inflation.

The value of a cubic metre of standing timber varies with the perspective of the investor. To the landowner that value is stumpage: the price that a willing buyer is prepared to pay for the right to cut. To the logger it is the difference between his log sales and his production costs, including profit and risk. To government that value is much higher where dependent industries provide employment, demand for capital, tax revenues and multiplier effects.

Not all species and products provide the same values—a cubic metre of wood is worth nothing, in a timber sense, it cannot be utilized profitably at its maturity. The valuation of wood to society is a complex question requiring more than is contained within this report. For our purposes 'economic value added' has been used as that measure. Value added is the value of the primary manufactured product, without secondary manufacture or multiplier minus the costs of fuel, energy and purchased goods utilized in its production. These values are shown by product and species in Appendix 3.

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[1] Pj_7Po_3 is the Ontario Forest Resources Inventory designation for a stand stocked 70% to jack pine and 30% to poplar.

Rotation ages throughout this report have been based on yield table culmination of mean annual increment, the usual practice in Ontario forestry.

Uses of The PV Model

The present value model may be used in the selection of a preferred treatment option from the various other alternatives which exist in the same area. Is it preferable to scarify for natural regeneration or site prepare and plant a jack pine class 1 site? What about a class 3 site? Is it preferable to accept poplar regeneration or convert to conifer on a good aspen site where aspen is a marketable item? The model has its greatest and simplest application for this purpose. It is possible to analyze these alternatives where the different treatment costs, failure rates, rotation ages, product values and yields are known.

The PV model may also be used to make comparisons between treatment options on different areas. Is limited silvicultural money best spent on site class 1 spruce despite its higher costs and failure rates, or on site class 3 despite its longer rotation age and lower productivity? Is it preferable to tend established plantations or to establish more new plantations? This use of the model is appropriate in the case where funding levels are insufficient to manage all of the production forest and where priorities must be established, a case all too familiar to most forest managers.

The model also has application in solving for unknowns, such as the yield gains required from genetically improved stock to justify the added investment burden. If these gains can be justified on class X and 1 sites but not on sites of lower productivity (where the costs remain the same but the yields are reduced and rotations lengthened), how large should the Ontario tree improvement program be? Alternatively, the model may be used to examine the extent to which the higher economic efficiency of close wood can offset the high costs of reclaiming older, grown-up cutovers.

Case Study No. 1 which follows is a working demonstration of the model. Practising foresters are encouraged to do their own tests of the PV model using practical questions which face them today and which silvicultural factors alone are unable to answer. Interest tables, inflation factors and value-added figures are provided in Appendices 1, 2 and 3 for this purpose.

An Uncertain Future

The long rotations of Ontario forestry require that we peer into a distant and uncertain future. What will be the forest products of the future? What will be their manufacturing processes and, more importantly for us, their raw material? What kind of a tree are we trying to grow?

These questions are quite aside from the function of our model, but they must be answered to fill in all of the model's blanks. Indeed, they must be answered by anyone planting a tree which will not mature for 60, 80, 100 years or even more. Of course diversification is an appropriate strategy in the face of uncertainty but it should not totally preclude that far-sighted look.

For the sake of simplicity the two case studies contained within this paper will assume that tomorrow looks like today. This is to avoid clouding the prime issue, demonstration of the model, and is not recommended as the normal course of action.

Case Study No. 1: The Alpha Forest (Solving for Close Land Reclamation Costs)

The Alpha Forest

The Alpha Forest is a tract of Crown land under a Forest Management Agreement and is situated in northern Ontario.

Black spruce is the characteristic and predominant species; the spruce working group represents over 80% of the production forest area. Black spruce occurs in large, pure stands on imperfectly drained clays and poorly drained organic soils over clay. On the better upland, well-drained clays black spruce grows in association with white spruce, balsam fir, trembling aspen and white birch. The spruce age class distribution is dominated by old-growth timber in N.S.R.[1] cutovers.

The Alpha Forest is the principal source of supply for a groundwood and sulphite operation which consumes 250,000 cunits of roundwood annually. The mill runs essentially on black spruce, although up to 10% of other conifers may be accepted. A quantity of spruce and jack pine sawlogs are produced and shipped to local sawmills. There is no significant demand for or utilization of hardwoods on the Forest.

The earliest cuts were made on high-yield upland sites close to the mill. These extremely productive sites, reported to have yielded up to 40 cords to the acre, tended to regenerate to aspen following clearcutting, and today the hills behind the mill are clothed in 60-year-old stands of pure poplar. Large-scale efforts at regenerating the spruce cutovers had begun by 1970 and by 1975 1.6 million trees were being planted annually. In 1982, 7,540 acres were site prepared, 7,280 acres planted and 6,963 tended on the Forest. Currently, the average distance of truck haul for wood from harvested forest to the mill is 60 miles. These cutovers are being regenerated in the following manner.

The most common silvicultural package in use on the Forest includes a mechanical site preparation of the fresh cutover using a D-8 bulldozer equipped with a shear blade followed by a hand planting of black spruce container stock at a rate of 700 trees per acre. The competitors to the planted spruce stock include poplar, grasses, raspberry, and white birch on the better (class X and 1) upland sites; the main competitor is alder on the (class 2) imperfectly drained shallow organic soils over clay. Little cutting and no regeneration effort is made on the deep, poorly drained organic soils which are class 3 sites according to Plonski, (1960). The site preparation and planting is often followed by a tending operation which is an aerial application of 2, 4-D herbicide to release the spruce from poplar and birch. The costs for each of these treatments, derived from silvicultural records, is shown in constant 1983 dollars on Table 1.

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[1] N.S.R.—Not Satisfactorily Regenerated.

Table 1: Alpha Forest
Summary of Silvicultural Treatment

Silvicultural Treatment	Cost per acre (Constant 1983 $)
Mechanical Site Preparation[1] (Shear blading)	$61.15
Container Stock[2]	$50.12
Tree Planting[1] (Container Stock)	$98.29
Tending[1] (2, 4-D herbicide applied aerially)	$11.31

[1]Based on a sample of 4,333 acres of treatment carried out between 1972 and 1977 and assessed between 1977 and 1982. The costs shown were derived from MNR silvicultural project records and inflated to constant 1983 dollars.

[2]Based on the average 1982 production cost of MNR greenhouses, excluding capital and some overhead, inflated to constant 1983 dollars and planted at 700 trees/acre.

The Question

The best sites and closest future wood opportunities exist in the upland clay soils of the earliest cutovers behind the mill. Those hills are forested today with 60-year-old, fully stocked site class 2 and 3 poplar containing an estimated 29.6 cunits per acre of unwanted wood[1]. The company wishes to explore the possibility of converting these sites back to spruce under intensive management. The average distance is six miles from the mill, but the poplar cannot be used in the Alpha Forest mill, nor can it be logged profitably and sold to other outlets. First, how much MNR silvicultural money could be diverted to the stand conversion and still maintain an economic efficiency equal to or better than current investment practice? Second, how much additional Company money could the future roundwood delivery save by logging close wood contribute to the project?

The analysis of the first part will be done by calculating the PV rating of the current silvicultural practice, which we shall call the 'Keep on Trucking' option. This PV value will then be inserted as the minimum acceptable value in the formula for the new proposal and the equation solved for the unknown, the maximum amount of silvicultural dollars which can be paid for an acre of land reclamation by poplar full-tree removal. We shall call the new proposal the 'Stand Conversion' option.

The second part of the question, the additional amount of Company money which could be contributed to the project will be determined by calculating the future roundwood delivery savings of Option No. 2 over Option No. 1 and discounting these values from the projected rotation age back to present.

The case study should be viewed only as a demonstration of the PV model's application and not as a definitive answer to a problem which undoubtedly requires further input.

[1]Based on the F.R.I. inventory, Ontario Normal Yield Tables and cull factors constrained in Ontario Cull Survey Tables.

Option No. 1: Keep On Trucking

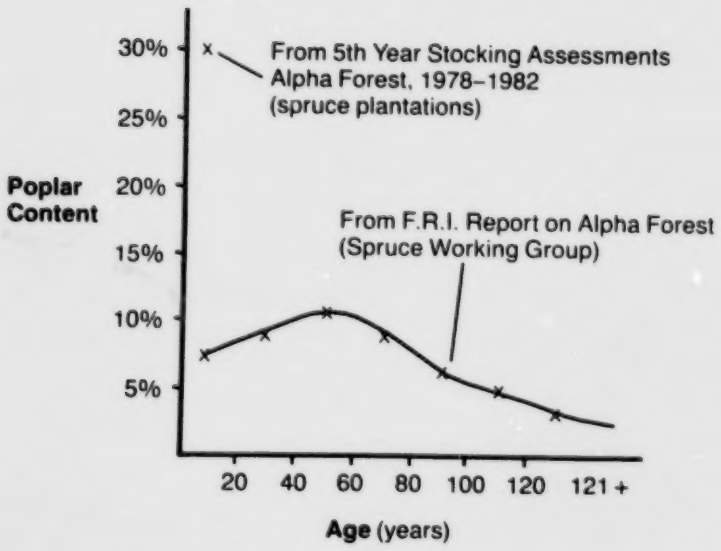
The 'Keep On Trucking' Option consists of a mechanical site preparation, planting and possible release on fresh cutovers as previously described, with costs as shown on Table 1. The average distance of today's effort is 60 miles from the mill.

An examination of all regeneration surveys carried out on this option within the past five years indicated the following information:

- 16.8% of the area so treated failed to meet the minimum stocking standards.
- On the area classified as satisfactorily restocked, the average species composition of the new stand was $Sb_5Po_3Sw_1Bf$, at age 5. The spruce averaged 2.8 feet in height, the poplar 7.1 feet. The overall stocking (all species) was 60%.
- Tending operations had been carried out on 32% of the treated area.
- 79% of the area treatment was made on site class 1 for spruce, 21% on site class 2.

There is some difficulty in projecting the species composition and stocking to maturity. F.R.I. Inventory shows volume by working group, species and age class. The Alpha Forest report depicted in Figure 1, suggests that the poplar content in young spruce stands tend to increase as the stands ages, peaks at about age 50, then declines as the poplar enters its age of break-up. If this parallel holds true, then our spruce plantations, which are 30% stocked to poplar at age 5, may become overgrown with poplar until after break-up age, 80 to 100 years from now.

Fig. 1: Alpha Forest Trends in Species Composition Over Time



This report however, does not represent a single acre of spruce over time but rather it shows the poplar content of different stands of different ages, the product of different forest eras. A special report run by site class did not show the same distinct pattern.

It is clear, from the regeneration assessments, however, that the 'new forest' has a higher poplar content than the old forest. Without attempting to answer these difficult questions, our model will assume that species composition is stable, but that overall stocking will increase by 50% from regeneration to maturity. Black Spruce Empirical Yield Tables (Smith, 1983) and Ontario Cull Survey Tables have been used to project rotation ages and net merchantable yields. The value-added figures for newsprint feedstock shown in Appendix 3 have been applied to the expected yield of black spruce and to the 10% limit of other conifers which the mill is able to accept. The expected poplar yield is calculated to be of no value to the market situation today.

The calculation for Option No. 1 is as follows:

$$PV = \left[\frac{Vh \times (1\text{-}R.F.)}{(1+i)^{nh}}\right] - \left[Ctr1 + \frac{Ctr2 + Ctr3}{(1+i)^{nr3}} + \left(\frac{Ctr4 \times P.T.}{(1+i)^{nr4}}\right)\right]$$

$$= -\$40.20/\text{acre}$$

Where PV = Present value

i = the interest rate
= 3% real (interest minus inflation)

Vh = the value at harvest using the following data and assuming a species composition at maturity of $Sb_5Po_3B_1Sw_1$.

	Site Class 1	Site Class 2	Average Site
G.T. Yield	3,754 cu. ft.	3,217 cu. ft.	3,641 cu. ft.
Rotation	85 years	100 years	88 years
stocking & rotation	0.9	0.9	0.9
Sb content (%)	50%	50%	50%
Other conifer limit	10%	10%	10%
Gross merch./gross total	0.665	0.710	0.674
Cull factor	1.6%	2.4%	1.8%
Site class mix	79%	21%	100%

= 3,641 cu. ft./acre × 0.9 stocking × 50% Sb content plus 10% limit on other conifers × 0.674 reduction to gross merch. × 0.981 reduction for cull × $228.75 value added/cunit × 1.0 distance and operability factor.

= $2,725.94/acre (for a yield of 11.9 cunits of conifer)

nh = rotation age
= 88 years

R.F. = the assessed rate of plantation failure 16.8%

Ctr1 = the cost of Treatment No. 1 (site preparation)
$61.15/acre for shear blading

Ctr2 = the cost of Treatment No. 2 (stock)
$71.60/M for MNR container stock planted at
700 trees per acre
$50.12/acre

Ctr3 = The cost of Treatment No. 3 (planting)
= $98.29/acre

ntr3 = the time to tree planting
= one year

Ctr4 = the cost of Treatment No. 4 (tending)
= $11.31/acre for 2, 4-D applied aerially

ntr4 = the time to tending
= four years

P.T. = the probability of tending treatment
= 32%

The fact that the net PV value is negative (-$40.20) is a reflection of the costs, interest rate, values, rotation ages and failure rates. This need not excessively concern the forest manager, provided that this represents a higher economic efficiency than his available alternate options. In this case, the negative value could be brought into the black if:

- the poplar content could be economically reduced or, conversely,
- the poplar were to be a product of value at rotation age,
- the stocking levels could be economically increased,
- the rotation age could be lowered,
- the silvicultural costs could be lowered.

However we assume that our manager has explored these alternatives, and that the calculation describes his most reasonable expectation for each of these factors.

Option No. 2: Stand Conversion Behind the Mill

The stand conversion option is a hypothetical one, untried and untested in the field. The silvicultural package consists of:

- land reclamation by poplar full-tree removal (the unknown cost) at year zero,
- chemical site preparation using 1 1/2 lbs. A.1./acre of "Round up" applied aerially at year one,
- hand planting of grafted black spruce improved stock at 1,200 trees per acre at year two,
- a refill planting of improved stock, assuming a 15% failure rate and 400 trees/acre at year four,
- a tending operation of 2,4-D applied aerially at year 5,
- a second tending operation will be required 50% of the time at year 10.

The estimated costs of these treatments is contained in the net PV calculation which follows.

Option No. 2 differs from the "Keep-on-Trucking Option" in several ways. First of all, it takes place on a better site; 60% of the area to be treated is site class X for spruce, 40% is site Class 1. Secondly, the silvicultural efforts are more intensive and the new stand is expected to be better: fully stocked to Sb_6Po_2 at its maturity. Thirdly, the timber to be grown will reside at an average distance of six miles from the mill as opposed to 60 miles.

The same yield tables, cull tables and value added are used as in Option No. 1, except that the yield has been adjusted upward by 15% to account for the use of improved stock, as suggested by Carlisle and Teich, 1970; Carlisle and Rauter, 1978. We shall assume a 5% rate of plantation failure.

The calculations for part one of the question, the maximum amount of silvicultural dollars which can be paid for an acre of land reclamation is as follows:—

$$PV = \$40.20/\text{acre}$$

$$\left[\frac{Vh \times (1\text{-}R.F.)}{(1+i)^{m}}\right] - \left[Ctr1 + \frac{Ctr2}{(1+i)^{m2}} + \frac{Ctr3 + Ctr4 +}{(1+i)^{m4}}\right.$$

$$\left.\left(\frac{Ctr5 \times Ptr5}{(1+i)^{m5}}\right) + \frac{Ctr6 +}{(1+i)^{m6}} \left(\frac{Ctr7 \times Ptr7}{(1+i)^{m7}}\right)\right]$$

Solving for Ctr1, the maximum amount of silvicultural dollars which can be paid for an acre of land reclamation, indicates Ctr1 = $69.57

Where: PV = Present Value

i = the interest rate
= 3% real (interest minus inflation)

Vh = the value of harvest using the following data and assuming a species composition at maturity of Sb_6Po_2.

	Site Class 1	Site Class 2	Average Site
G.T. Yield	3,181 cu. ft.	3,754 cu. ft.	3,410 cu. ft.
Rotation	60 years	85 years	70 years
Stocking & Rotation	1.0	1.0	1.0
Sb content (%)	80%	80%	80%
Gross merch/gross total	0.66	0.66	0.66
Cull factor	0.5%	1.6%	0.9%
Site Class mix	60%	40%	100%

= 3,110 cu. ft./acre × 1.0 stocking × 80% Sb content × 0.66 reduction to gross merch. × 0.991 reduction for cull × $228.75 value added/cunit × 1.0 distance and operability factor × 1.15 adjustment for improved stock.
= $4,693.76/acre (for yield of 20.5 cunits of spruce).

nh = rotation age
= 70 years

R.F. = the estimated rate of plantation failure
= 5%

Ctr1 = the cost of Treatment No. 1, the maximum amount of silvicultural dollars which can be paid for an acre of land reclamation by poplar full-tree removal

Ctr2 = the cost of Treatment No. 2 (site preparation)
= $58.23/acre for 1½ lbs A.1/acre Round-up applied aerially

ntr2 = the time to site preparation
= one year

Ctr3 = the cost of Treatment No. 3 (improved stock)
= $236.60/M for MNR grafted improved stock planted @ 1,200 trees/acre
= $283.92/acre

Ctr4 = the cost of Treatment No. 4 (planting)
= $141.78/M × 1.1 adjustment for a quality job
= $187.16/acre

ntr4 = the time to tree planting
= two years

Ctr5 = the cost of Treatment No. 5 (refill planting)
= $236.60/M for stock plus ($156.96/M for planting @ 400 trees/acre
= $157.42/acre

ntr5 = the time to refill
= four years

Ptr5 = the probability of refill planting taking place
= 15%

Ctr6 = the cost of Treatment No. 6 (tending)
= $11.31/acre for 2, 4-D applied aerially

ntr6 = the time to first tending
= five years

Ctr7 = the cost of Treatment No. 7 (tending)
= $11.31/acre for 2, 4-D applied aerially

ntr7 = the time to second tending
= ten years

Ptr7 = the probability of a second tending treatment
= 50%

i.e., If all of the input data are correct, the Ministry of Natural Resources could afford to divert up to $69.57 of its silvicultural money for each acre of stand conversion and still maintain an economic efficiency equal to its current investment practice. This amounts to $2.35 for each of the estimated 29.6 cunits of poplar to be removed from the site.

There is a second part to the question. What is the present value of the log delivery savings that the Company will receive as a result of logging close wood at the end of the rotation, as opposed to trucking the additional 54 miles of Option No. 1?

The $69.57 MNR calculation just completed does not recognize that the timber grown by option No. 2 is more valuable because of its proximity to the Alpha Forest mill. In fact, the wood is not worth any more to the Ministry of Natural Resources in its new location, but it will be to the Company when harvested. That value is calculated as follows:—

$$PV = \frac{Vhs \times (1\text{-}R.F.)}{(I+i)^{nh}}$$

$$= \$49.19/\text{acre}$$

Where: PV = Present value

Vhs = the value of harvest (log delivery) savings
= 20.5 cunits/acre × $20.00/cunit
= $410.00/acre

R.F. = the estimated rate of plantation failure
= 5%

nh = rotation age
= 70 years

The Conclusion

The modelling of all the data input suggests that the Ministry of Natural Resources could divert up to $69.57 per acre for stand conversion and the Company could place up to $49.19 for a total of $118.76 per acre. This amounts to $2.35 and $1.66, respectively, for each cunit of poplar estimated on site, for a total of $4.01.

It is at this point that the forest manager should allow himself second thoughts on the data input and, if the proposal appears to be viable, pursue the comparison with more refined data.

Table 3a: Beta Management Unit Poplar PV Calculations (All Soil Types Combined)

	Site Class 1	Site Class 2	Site Class 3
SILVICULTURAL PACKAGE	S-1	S-1	S-1
Site preparation @ Present			
Container Stock @ Year 1			
Planting @ Year 1			
Chemical cleaning (aerial)			
Probability of Tending			
PV of Silvicultural Costs	Nil	Nil	Nil
5th YEAR ASSESSMENT RESULTS			
Rate of Failure	0%	0%	0%
Species Composition (successes)	Po_{10}	Po_{10}	Po_{10}
Stocking Factor (successes)	1.0	1.0	1.0
THE STAND AT MATURITY			
Rotation Age	55 years	60 years	65 years
Estimated Species Composition	Po_{10}	Po_{10}	Po_{10}
Estimated Stocking Factor	1.0	1.0	1.0
Gross Merch. Yield[1] (cu.ft./ac.)	4,347 cu. ft.	3,962 cu. ft	2,904 cu. ft.
Cull Factor[2]: Jack Pine Poplar Black Spruce Balsam Fir	8.85%	9.80%	10.85%
Net Yield: Jack Pine Poplar Black Spruce Balsam Fir	3,962 cu. ft.	3,574 cu. ft.	2,589 cu. ft.
Total	3,962 cu. ft.	3,574 cu. ft.	2,589 cu. ft.
Value at Harvest[3]: Jack Pine Poplar @ $81.38/cunit Black Spruce Balsam Fir	$3,224.28	$2,908.52	$2,106.93
Total	$3,224.28	$2,908.52	$2,106.93
M.A.I. (cu. ft./ac./year): Jack Pine Poplar Black Spruce Balsam Fir	72.0	59.6	39.8
Total	72.0	59.6	39.8
M.A.I. (Dollars/acre/year)	$ 58.62	$ 48.47	$ 32.41
P.V. of Harvest Values	$634.44	$493.67	$308.48
NET PV RATING	$634.44	$493.67	$308.48

[1]Based on Normal Yield Tables for Ontario, Plonski 1960.

[2]Based on Cull Survey Tables, 1974.

[3]Based on the value in Appendix 3, adjusted for the forest product mix.

Table 3b: Beta Management Unit Jack Pine PV Calculations (Deep, Fine and Medium Sands)

	Site Class 1	Site Class 2	Site Class 3
SILVICULTURAL PACKAGE	S-2	S-4	S-4
Site preparation @ Present	$ 35.08/ac.	$ 35.08/ac.	$ 35.08/ac.
Container Stock @ year 1	$ 71.60/ac.	$ 71.60/ac.	$ 71.60/ac.
Planting @ year 1	$ 76.66/ac.	$ 76.66/ac.	$ 76.66/ac.
Chemical cleaning (aerial) @ year 6	$ 13.56/ac.		
Probability of Tending	40%		
PV of Silvicultural Costs	$183.56/ac.	$179.02/ac.	$179.02/ac.
5th YEAR ASSESSMENT RESULTS			
Rate of Failure	11.2%	11.2%	11.2%
Species Composition (successes)	$Pj_7Po_2Sb_1$	$Pj_7Po_2Sb_1$	$Pj_7Po_2Sb_1$
Stocking Factor (successes)	0.8	0.8	0.8
THE STAND AT MATURITY			
Rotation Age	45 years	60 years	70 years
Estimated Species Composition	$Pj_7Po_2Sb_1$	$Pj_7Po_2Sb_1$	$Pj_7Po_2Sb_1$
Estimated Stocking Factor	1.0	1.0	1.0
Gross Merch. Yield[1] (cu.ft./ac.)	2,549 cu. ft.	2,312 cu. ft	1,811 cu. ft.
Cull Factor[2]: Jack Pine	0.15%	0.60%	1.10%
Poplar	7.00%	9.80%	11.90%
Black Spruce	0.15%	0.50%	0.80%
Balsam Fir			
Net Yield[3]: Jack Pine	1,582 cu. ft.	1,429 cu. ft.	1,114 cu. ft.
Poplar	421 cu. ft.	370 cu. ft.	283 cu. ft.
Black Spruce	226 cu. ft.	204 cu. ft.	160 cu. ft.
Balsam Fir			
Total	2,229 cu. ft.	2,003 cu. ft.	1,557 cu. ft.
Value at Harvest[4]: Jack Pine @ $115.15/cunit	$1,822.15	$1,645.25	$1,282.77
Poplar @ $81.38/cunit	$ 342.54	$ 301.34	$ 230.31
Black Spruce @ $228.75/cunit	$ 516.98	$ 467.20	$ 366.00
Total	$2,681.67	$2,413.79	$1,879.08
M.A.I. (cu. ft./ac./year): Jack Pine	35.2	23.8	15.9
Poplar	9.3	6.2	4.1
Black Spruce	5.1	3.4	2.3
Balsam Fir			
Total	49.6	33.4	22.3
M.A.I. (Dollars/acre/year)	$ 59.59	$ 40.23	$ 26.23
P.V. of Harvest Values	$709.14	$409.70	$237.32
NET PV RATING	$525.58	$230.68	$ 58.30

[1]Based on Normal Yield Tables for Ontario, Plonski 1960.

[2]Based on Cull Survey Tables, 1974.

[3]Reductions have been made to account for the rate of failure.

[4]Based on the value in Appendix 3, adjusted for the forest product mix

Table 3c: Beta Management Unit Jack Pine PV Calculations (Sandy Loam Till Soils)

	Site Class 1	Site Class 2	Site Class 3
SILVICULTURAL PACKAGE	S-3	S-5	S-6
Site Preparation @ Present	$ 50.11/ac.	$ 50.11/ac.	$ 50.11/ac.
Container Stock @ year 1	$ 71.60/ac.	$ 71.60/ac.	$ 71.60/ac.
Planting @ year 1	$ 82.41/ac.	$ 82.41/ac.	$ 82.41/ac.
Chemical cleaning (aerial) @ year 6	$ 13.56/ac.	$ 13.56/ac.	
Probability of Tending	90%	80%	
Silvicultural Costs	$209.85/ac.	$208.71/ac.	$199.63/ac.
5th YEAR ASSESSMENT RESULTS			
Rate of Failure	11.2%	11.2%	11.2%
Species Composition (successes)	$Pj_5Po_4B_1$	$Pj_5Po_4B_1$	$Pj_5Po_4B_1$
Stocking Factor (successes)	0.8	0.8	0.8
THE STAND AT MATURITY			
Rotation Age	45 years	60 years	70 years
Estimated Species Composition	$Pj_5Po_4B_1$	$Pj_5Po_4B_1$	$Pj_5Po_4B_1$
Estimated Stocking Factor	1.0	1.0	1.0
Gross Merch. Yield[1] (cu.ft./ac.)	2,549 cu. ft.	2,312 cu. ft	1,811 cu. ft.
Cull Factor[2]: Jack Pine	0.15%	0.60%	1.10%
Poplar	7.00%	9.8 %	11.9 %
Black Spruce			
Balsam Fir	1.35%	4.50%	6.30%
Net Yield[3]: Jack Pine	1,130 cu. ft.	1,020 cu. ft.	795 cu. ft.
Poplar	842 cu. ft.	741 cu. ft.	567 cu. ft.
Black Spruce			
Balsam Fir	223 cu. ft.	196 cu. ft.	151 cu. ft.
Total	2,195 cu. ft.	1,957 cu. ft.	1,513 cu. ft.
Value at Harvest[4]: Jack Pine @ $115.15/cunit	$1,301.20	$1,174.53	$ 915.44
Poplar @ $81.38/cunit	$ 685.22	$ 603.03	$ 461.42
Black Spruce			
Total	$1,986.42	$1,777.56	$1,376.86
M.A.I. (cu. ft./ac./year): Jack Pine	25.1	17.0	11.4
Poplar	18.7	12.4	8.1
Black Spruce			
Balsam Fir	5.0	3.3	2.2
Total	48.8	32.7	21.7
M.A.I. (Dollars/acre/year)	$ 44.14	$ 29.62	$ 19.67
P.V. of Harvest Values	$525.29	$301.54	$173.89
NET PV RATING	$315.44	$ 92.83	–$ 25.74

[1]Based on Normal Yield Tables for Ontario, Plonski 1960.

[2]Based on Cull Survey Tables, 1974.

[3]Reductions have been made to account for the rate of failure.

[4]Based on the value in Appendix 3, adjusted for the forest product mix.

Table 4: Beta Management Unit Forest Production Policy

		Jack Pine Work	
		Site Class 1 +	Site Class 2
1. DEEP FINE AND MEDIUM SANDS Generally well-drained sands of various textures, with a moderately fresh to very fresh moisture regime.	Present Production Area (acres)	21,888	19,390
	Potential Production Area (acres)	36,076	31,832
	Silvicultural Package	S-2	S-4
	PV Rating	$525.58	$230.68
	Production Area Allocation (acres)	35,189	22,772
	M.A.I. (cunits):		
	Jack pine	12,387	5,420
	Poplar	3,273	1,412
	Black spruce	1,795	774
	Balsam fir		
	Total	17,455	7,606
	M.A.I. (dollars)	$2,096,913	$916,118
2. SHALLOW SANDS AND SANDY LOAMS OVER BEDROCK Well-drained to imperfectly drained sandy till soils, with a moderately fresh to moderately moist and variable moisture regime, depending on soil depth, slope position and depressions in the underlying bedrock	Present Production Area (acre)	4,942	9,098
	Potential Production Area (acres)	8,067	15,125
	Silvicultural Package	S-3	S-5
	PV Rating	$315.44	$92.83
	Production Area Allocation (acres)	6,276	10,160
	M.A.I. (cunits)		
	Jack pine	1,575	1,727
	Poplar	1,174	1,260
	Black spruce		
	Balsam fir	314	335
	Total	3,063	3,322
	M.A.I. (dollars)	$277,023	$300,939
3. DEEP SANDY LOAM TILLS Deep, stoney sandy loam tills of various drainage classes and moisture regimes	Present Production Area (acres)	1,460	3,847
	Potential Production Area (acres)	2,542	6,247
	Silvicultural Package	S-3	S-5
	PV Rating	$315.44	$92.83
	Production Area Allocation (acres)	1,811	4,114
	M.A.I. (cunits):		
	Jack pine	455	699
	Poplar	339	510
	Black spruce		
	Balsam fir	91	136
	Total	885	1,345
	M.A.I. (dollars)	$79,938	$121,857
4. DEEP SILT LOAMS Generally imperfectly to poorly drained soils, with a very fresh to very moist moisture regime	Present Production Area (acres)	2,785	4,523
	Potential Production Area (acres)	6,135	10,037
	Silvicultural Package	S-3	S-5
	PV Rating	$315.44	$92.83
	Production Area Allocation (acres)	3,794	4,345
	M.A.I. (cunits):		
	Jack pine	953	739
	Poplar	709	539
	Black spruce		
	Balsam fir	189	143
	Total	1,851	1,421
	M.A.I. (dollars)	$167,467	$128,699
5. ALL SOIL TYPES COMBINED			
	Present Production Area (acres)	31,075	36,858
	Production Area Allocation (acres)	47,070	41,391
	M.A.I. (cunits)		
	Jack pine	15,370	8,585
	Poplar	5,495	3,721
	Black spruce	1,795	774
	Balsam fir	594	614
	Total	23,254	13,694
	M.A.I. (dollars)	$2,621,341	$1,467,613

ing Group		Poplar Working Group				
Site Class 3	Total	Site Class 1 +	Site Class 2	Site Class 3	Total	Grand Totals
1,937	43,215	1,391	14,569	11,562	27,522	70,737
2,829	70,737	1,738	18,171	14,422	34,331	70,737
		S-1	S-1			
		$634.44	$493.67			
nil	57,961	1,738	9,000	nil	10,738	68,699
	17,807					17,807
	4,685	1,251	5,364		6,615	11,300
	2,569					2,569
	25,061	1,251	5,364		6,615	31,676
	$3,013,031	$101,882	$436,230		$538,112	$3,551,143
1,220	15,260	476	4,101	5,372	9,949	25,209
2,017	25,209	582	5,015	6,570	12,167	25,209
		S-1	S-1			
		$634.44	$493.67			
nil	16,436	582	5,015	nil	5,597	22,033
	3,302					3,302
	2,434	419	2,989		3,408	5,842
	649					649
	6,385	419	2,989		3,408	9,793
	$577,962	$34,117	$243,077		$277,194	$855,156
244	5,551	160	2,209	1,858	4,227	9,778
489	9,778	189	2,623	2,207	5,019	9,778
		S-1	S-1			
		$634.44	$493.67			
nil	5,925	189	2,623	nil	2,812	8,737
	1,154					1,154
	849	136	1,563		1,699	2,548
	227					227
	2,230	136	1,563		1,699	3,929
	$201,795	$11,079	$127,137		$138,216	$340,011
1,038	8,346	462	5,881	3,899	10,242	18,588
2,417	18,588	516	6,574	4,359	11,449	18,588
		S-1	S-1			
		$634.44	$493.67			
nil	8,139	516	6,574	nil	7,090	15,229
	1,692					1,692
	1,248	372	3,918		4,290	5,538
	332					332
	3,272	372	3,918		4,290	7,562
	$296,166	$30,248	$318,642		$348,890	$645,056
4,439	72,372	2,489	26,760	22,691	51,940	124,312
nil	88,461	3,025	23,212	nil	26,237	114,698
	23,955					23,955
	9,216	2,178	13,834		16,012	25,228
	2,569					2,569
	1,208					1,208
	36,948	2,178	13,834		16,012	52,960
	$4,088,954	$177,326	$1,125,086		$1,302,412	$5,391,366

Jack pine package S-2 on the deep sands had the second-best PV rating at $528.58, again on any class 1 site. The potential area for this option was 36,076 acres, but some of this has now been lost to the poplar working group.

The running balance of potential production area has fallen to 35,189 acres, so we allocate this amount to growing jack pine and deplete the remaining landbase as before. Our running total of annual production level is now 5,451 units of poplar, 12,387 cunits of jack pine and 1,795 cunits of black spruce.

Poplar package S-1 on class 2 sites is next with a PV rating of $493.67. If all of the potential production area were allocated to poplar production we would over produce the poplar target and leave insufficient area for jack pine production, so all of the potential till soils and only 9,000 acres of the deep sands is put into poplar. (The deep sands are held back rather than the tills because the jack pine PV rating is higher there). The remaining landbase is depleted as before. Our running total of annual production is now 19,285 cunits of poplar, 12,387 cunits of jack pine and 1,795 of spruce. At this point our model stops intentionally growing poplar and concentrates on jack pine; the poplar deficit will be made up as a by-product of jack pine production.

Jack pine packages S-3, S-4 and S-5 are then added progressively to the running total until the volume targets have been met. As this run turned out, the targets for jack pine and poplar are met without having to make efforts on class 3 sites. There is however, a spruce shortfall.

Table 5, the Beta Unit Implementation Schedule, then translates all of the S-1 to S-5 packages into their site preparation, regeneration and tending components. This is the level of silvicultural effort and funding needed to produce the annual volumes shown underlined in the lower right corner of Table 4, assuming a 'normal' rate of cutting and regeneration i.e., without acceleration or deceleration.

Conclusions

The current intuitive practice of permitting poplar to gain new ground on the best poplar sites appears to have a sound economic basis. The jack pine working group will have to be expanded overall from 72,372 acres to 88,461 to meet the jack pine volume target, however, and this is best done on the deep sands where the treatment costs are lower and the results better. (This area expansion may result at least in part from our projection that the new jack pine forest will have a 25% poplar content, whereas the F.R.I. data reveal the old forest to contain only 9.6%). There is always time to pose second thoughts on the regional silvicultural packages or on other data input at this point.

Spruce is produced as a by-product of jack pine management on some sites but has fallen short of its target by 6,400 cunits annually. If that spruce volume is important to the Unit, management efforts will be required in the spruce working group also.

Table 5: Beta Management Unit 'Ideal' Production Policy Annual Implementation Schedule Based on Application of Economic Methodology

	Jack Pine W.G.'		Poplar W.G.'	
	Acres	**Dollars**	**Acres**	**Dollars**
Natural Regeneration			442	Nil
Mechanical Site Preparation	1,736	$ 73,000		
Container Stock (trees)	1,736M	$124,300		
Tree Planting	1,736	$136,800		
Tending	799	$ 10,800		
		$344,900	442	Nil

'Working Group

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Appendix 1: 3% Interest Rates

n	$(1+i)^n$	n	$(1+i)^n$
1	1.0300	51	4.5154
2	1.0609	52	4.6509
3	1.0927	53	4.7904
4	1.1255	54	4.9341
5	1.1593	55	5.0821
6	1.1941	56	5.2346
7	1.2299	57	5.3917
8	1.2668	58	5.5534
9	1.3048	59	5.7200
10	1.3439	60	5.8916
11	1.3842	61	6.0684
12	1.4258	62	6.2504
13	1.4685	63	6.4379
14	1.5126	64	6.6311
15	1.5580	65	6.8300
16	1.6017	66	7.0349
17	1.6528	67	7.2459
18	1.7024	68	7.4633
19	1.7535	69	7.6872
20	1.8061	70	7.9178
21	1.8603	71	8.1554
22	1.9161	72	8.4000
23	1.9736	73	8.6520
24	2.0328	74	8.9116
25	2.0938	75	9.1789
26	2.1566	76	9.4543
27	2.2213	77	9.7379
28	2.2879	78	10.0301
29	2.3566	79	10.3310
30	2.4273	80	10.6409
31	2.5001	81	10.9601
32	2.5751	82	11.2889
33	2.6523	83	11.6276
34	2.7319	84	11.9764
35	2.8139	85	12.3357
36	2.8983	86	12.7058
37	2.9852	87	13.0870
38	3.0748	88	13.4796
39	3.1670	89	13.8839
40	3.2620	90	14.3005
41	3.3599	91	14.7295
42	3.4607	92	15.1714
43	3.5645	93	15.6265
44	3.6715	94	16.0953
45	3.7816	95	16.5782
46	3.8950	96	17.0755
47	4.0119	97	17.5878
48	4.1323	98	18.1154
49	4.2562	99	18.0589
50	4.3839	100	19.2186

Appendix 2: Adjustment Factors to Constant 1983 Dollars

Year of Expenditure	Adjustment Factor
1983	1.000
1982	1.106
1981	1.218
1980	1.353
1979	1.492
1978	1.589
1977	1.701
1976	1.863
1975	2.063
1974	2.378
1973	2.595
1972	2.725
1971	2.812
1970	2.973

Appendix 3: Economic Value Added by Species and Product 2nd Quarter, 1983

Species and Product	Product Price ($Cdn)[1]
Spruce-Pine-Fir 2 x 4 lumber (plus chips)	$220/mf.b.m. (lumber) plus $543/ton (kraft)
Waferboard (aspen)	$187/m sq. ft. (7/16 in. basis)
Medium density board (aspen)	$250/m sq. ft. (5/8 in. basis)
Poplar plywood (construction grade)	$445/m sq. ft. (1/2 in. basis)
Newsprint pulp (spruce)	$500/ton
Bleached softwood kraft pulp	$543/ton
Bleached heavy hardwood kraft pulp	$469/ton
Bleached hardwood kraft pulp (aspen)	$469/ton

[1]Industry averages, 2nd quarter 1983, f.o.b. producing mill

[2]From a sampling of MNR mill licence returns, 1982–83

[3]The ratio of value of shipments to value added, from Statistics Canada data, 1982

Yield and Conversion Factors[2]	Ratio of VA/VS[3]	Value Added per cunit
555 f.b.m. + 0.56 o.d. tons chip/cunit	0.415	$115.15
1161 sq. ft./cunit (7/16-in. basis)	0.366	$ 79.67
813 sq. ft./cunit (5/8-in. basis)	0.366	$ 74.39
832 sq. ft./cunit (1/2-in. basis)	0.532	$196.85
0.83 ton/cunit	0.549	$228.75
0.54 ton/cunit	0.462	$135.47
0.77 ton/cunit	0.462	$166.84
0.46 ton/cunit	0.462	$ 99.68